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Kentucky Geological Survey

CHARLES J. NORWOOD, Director.

REPORT

ON THE

Progress of the Survey

FOR THE YEARS 1910 AND 1911

By CHARLES J. NORWOOD

LEXINGTON, KENTUCKY.

1912

LETTER OF SUBMITTAL.

To His Excellency, JAMES B. McCREARY,
Governor of Kentucky.

Sir: I have the honor to submit the following report on the operations of the State Geological Survey for the calendar years 1910 and 1911, for your consideration and transmittal to the General Assembly.

Very respectfully,

CHARLES J. NORWOOD,

Director.

January 9, 1912.

PERSONNEL OF THE SURVEY.

The following persons now hold or have held positions on the Survey during the period covered by this report. They are named in the order of their appointment under each class.

Director.—Charles J. Norwood.

Assistants in Geology.—August F. Foerste, Julius F. Fohs, Leonidas C. Glenn, James H. Gardner. James M. Hodge was employed in writing his report for a time in 1910. Albert R. Crandall was employed for a few months in 1910, in reproducing a report that had been lost. F. M. Hutchinson was employed in the field for a short time in 1910, and in writing his report (to which he did not give his time continuously) in 1910 and 1911.

Chemistry, Technology, and Soils.—Alfred M. Peter, supervising chemist and in charge of soil testing; Harry D. Easton, assistant in clay testing; James H. McHargue, chemist; Sadocia C. Jones, assistant in soils, and Ralph D. Quickel, (resigned February 1, 1911), aid in fuel testing.

Oil and Gas.—Kessack D. White.

Office.—F. Grider McKay, clerk; Nancy D. Bentley, stenographer.

Drafting.—Joseph W. Norwood.

Temporary Aids.—The following were employed for various periods as temporary aids in 1910: Lucian Walker, C. K. Bain, Phil Holloway, D. W. Smith, and W. B. Paynter, as field aids. R. G. Stevens, in the Museum. The following were employed in 1911 for various periods: C. E. Straub, Lucian Walker, R. M. Woodson, W. B. Paynter, as field aids. In collecting mineral statistics in co-operation with the U. S. Geological Survey the following were employed at different times (only one being employed at a time), R. G. Stevens, C. K. Bain, H. A. Kohnhorst, W. B. Hager. Mr. C. P. Kennedy is employed in keeping gage records of the Dix river.

In the co-operative topographic mapping large field parties were employed, under the direction of topographers of the U. S. Geological Survey. It is not deemed necessary to give the long list of names here.

REPORT OF PROGRESS.

Since its resumption the work of the Survey has been vigorously prosecuted along the lines laid out in the law, and many reports and maps dealing with the economic resources of the State have been completed. Reports for twenty-eight volumes known as Bulletins (some of the latter containing several reports) together with six County Reports each forming a volume, have been prepared. Unfortunately, however, the printing has by no means kept pace with the preparation of the reports and maps—a circumstance for which, of course, the Director is in no wise responsible. This matter is discussed on another page.

Manifestly, with limitations in the matter of funds available for each year, it has been impossible to at once take up all the subjects named in the law; nor has it been possible to place work each season in all the regions needing it, nor to at once comply with all requests for the examination of particular localities. The character of work that has been carried on so far has been determined not alone by personal knowledge on the part of the Director of the needs of the State, but also by the tenor of inquiries of correspondents seeking information concerning the resources of the State, by conferences with men interested in the development of the State, and by some suggestions received from the late Nathaniel S. Shaler, based on his experience as Director of the Survey from August, 1873, to April, 1880, under whom the present Director served as an assistant geologist for six years.

If the older method of issuing volumes made up of miscellaneous reports were followed, the published Bulletins (as the volumes dealing with single subjects or regions are now called) on geological resources, together with the biennial reports (which contain matter relating to economic resources in addition to that relating to administration), would make five volumes of convenient size (equal to an average of 425 pages

each); and the material in the hands of printers would make about as many more.

The published Bulletins, with maps, include reports on the coals of the Big Sandy Valley, on those of the region drained by the Three Forks of the Kentucky river, on those of the Licking Valley and some of the contiguous region (including Elliott and Menefee counties), and on those along the western margin of the Eastern Coalfield. Also reports on our oil and gas horizons, on some of our clay areas, on the lead and zinc rocks of central Kentucky, on our fluorspar deposits, and on the character and economic values of some of the lower formations of the State. Reports on the coals of the Poor and Clover Forks of the upper Cumberland river (in Harlan and Letcher counties), and on those of the Pineville Gap and Log Mountains region (in Bell and Knox counties) have long been ready for publication, and have been in the printer's hands since about July 31, last. Similar reports have been prepared on a large part of the Western Coalfield; their publication has been ordered, and it is understood that arrangements have been perfected for printing them. They include reports on the coals of the region drained by the Tradewater river (about 800 square miles), on those in the region covered by the Central City, Madisonville, Calhoun, and Newberg quadrangles, and (a brief account) on those within the Hartford quadrangle. Other reports that have been prepared and are now in the hands of printers are named on another page. An elaborate report on the Cincinnati formation, which covers so large a portion of the State, and its economic values, was prepared, but (with three others) it was lost while in the hands of a former contractor for the public printing.

Most of the reports named, while comprehensive and in considerable detail, are necessarily largely preliminary in character; they were issued to meet immediate necessities and must be followed by others giving greater detail, which, however, can be worked out only as we get accurate maps, of the sort now being made by the State and Federal Surveys in co-operation.

A new geological map of the State has been issued, also. The base for the map was compiled and drawn by J. B. Hoeing; delineation of the geological formations is in accordance with

data furnished by the various geologists that have served on the Survey under past and present administrations. Sufficient data have been gathered since publication of the map of 1907 to warrant preparation of a revised edition; indeed, it is very desirable that such an edition be issued.

Following is an account of the operations of the Survey during the two calendar years 1910 and 1911.

GEOLOGICAL AND TECHNOLOGICAL WORK.

1. *Central City, Madisonville, Calhoun, and Newberg Quadrangles.*—Field work for reports on these quadrangles, embracing an area of about 800 square miles in the heart of the Western Coalfield, was completed by F. M. Hutchinson in the spring of 1910. This work has revealed a larger number of workable coals in the upper series of beds and larger fields of thick coals than had been known to exist. The reports, forming one large Bulletin, are accompanied by maps showing the areas of the important coal beds from "No. 9" up to "No. 15," inclusive; outcrop lines are delineated, and general ground structure, including some lines of faulting, is indicated. The Bulletin was completed in 1911 and is in the printers hands, with an understanding that it is to come from the press in about four months.

2. *Rockcastle County.*—The field work for a report on the economic resources and soils of Rockcastle county was completed in 1910, the geology by F. Julius Fohs and the soil investigations by S. C. Jones, with Lucian Walker serving as field aid. The work in Rockcastle county has not only proven the richness of that county in thick and extensive beds of very high-grade oolitic and blue limestones and of "freestone," valuable deposits of clay, and great beds of sandstone that yield excellent sands for various purposes (including bottle glass), but it revealed the fact that the coal area of the southern and eastern portions of the county instead of being practically exhausted, as has been reported hitherto, still contain a large amount of good coal. It was found that the Conglomerate Sandstone measures, which carry two and sometimes three good coals, cover 53,700 acres. The average intervals between the coals, as determined by Mr. Fohs, are as follows:

The Corbin Conglomerate (72 ft.)	
Interval, 91 ft.	
Corley Hollow Coal.....	36 in.
Interval, 144 ft.	
New Livingston Coal.....	8 to 32 in.
Interval, 77 ft.	
Livingston Coal.....	36 in.
Interval, 64 ft.	
Mississippian Limestone and Shales.	Base.

The acreage estimated for the respective seams is 40,000 for the Livingston; 28,000 for the New Livingston, and 5,000 for the Corley Hollow, of which not over 1,000 acres have been exhausted, leaving approximately 176,000,000 tons of coal yet to be recovered. Though the seams are, as a rule, thin, it is to be borne in mind that even now coals having no greater thickness are being worked in many regions, that all beds of coal are growing in value, and that these Rockcastle beds have an especial importance in connection with possibilities for the establishment of clay, cement, lime, and other industries that the resources of the county so well justify. The report has been ready since the fall of 1910, but publication delayed by circumstances that the Director of the Survey could not control (see statement about publications on another page); it is now in the printer's hands, with promise that it will be sent through the press within about four months.

3. *Lewis and Rowan Counties.*—A geological survey of Lewis and Rowan counties was completed in 1910, by F. Julius Fohs. An excellent showing is made by these counties in the way of high-grade structural stone (freestone), useful shales and clays, and road material. Favorable structure for oil and gas was also noted. More particular reference is made to the occurrences of freestone and oil and gas possibilities under appropriate heads elsewhere in this report. Much interest has been manifested in the occurrence of zinc ore in Lewis. The ore (zinc blende, sometimes partly altered to zinc carbonate) occurs in what it is known as the West Union limestone of the Niagaran series, either in the form of nodules or as a cementing material in thin seams in the brecciated beds. A special article on these zinc occurrences has been prepared by Mr. Fohs for

the Miscellaneous Bulletin for which material is in hand. The conclusion reached is that, while the ore is of good quality, it is not likely to be found in profitable quantity except locally. That any bed to be workable must be not less than three or four feet thick and carry at least 10 per cent. of ore. The region south of Concord is not deemed worthy of further prospecting; but "at Martin and in the Salt Lick valley region (four miles south of Vanceburg) further prospecting will be necessary to prove whether or not the deposits are of value, and this prospecting must be done in the more promising unweathered beds." The report on Lewis and Rowan is in the printer's hands.

4. *Pineville Gap Region.*—A report which had been prepared by A. R. Crandall and G. M. Sullivan on the Pineville Gap region in Bell and Knox counties, including the Log Mountains, Straight Creek and its branches, Stewarts Branch, and Fourmile Creek in Bell county; and Greasy, Brush, and Stinking creeks in Knox county, was lost by a former contractor for the public printing. It was reproduced by Prof. Crandall (requiring some field work in 1910), and has been in the printer's hands since about July 31, 1911.

5. *Hartford Quadrangle.*—Geological field work in the Hartford quadrangle (about 238 square miles) was completed in 1910-11, by J. H. Gardner. It is advisable that the report on that quadrangle shall form part of a Bulletin embracing at least one other quadrangle. A preliminary report with special reference to coals, oil, and gas, to serve until the detailed report for the Bulletin shall have been completed, has been turned over for publication and there is promise of its appearance by next May. While the report is condensed, it has several page maps showing areas of various coals and it will prove useful to prospectors. The work in this quadrangle has shown a larger area of workable coal in the western portion of the quadrangle than has hitherto been definitely known.

6. *Webster County.*—Geological field work in the Webster county area—an area typical of disturbed regions within the Western Coalfield—was completed by L. C. Glenn in 1910-11. The report is not quite ready for publication. Because of the increasing interest in this important region, concerning which there is little accurate information available in printed

form, a brief abstract from those portions of the report dealing with stratigraphy, structure, and economic resources is given in this report.

7. *Region of the Quicksand Creeks.*—Field work for a report on the coals of the region drained by the Quicksand creeks, lying in Breathitt and parts of Knott and Floyd counties, was completed by Mr. Fohs in 1911. The report is in the hands of the printer and is expected from the press within about four months. The region covers an area of approximately 130,000 acres (about 203 square miles) in which occur eleven beds of coal, including cannels. Mr. Fohs reports the net thicknesses of the coals, with the average intervals between beds, as follows:

Hindman Coal (uppermost bed)	72 inches
Interval, 60 ft.	
Flag Coal	36 inches.
Interval, 60 ft.	
Hazard Coal	72 inches.
Interval, 145 ft.	
Leatherwood Coal. Thin.	
Interval, 47 ft.	
Haddix Coal	36 inches.
Interval, 68 ft.	
Dean (or Fireclay) Coal.....	36 inches.
Interval, 45 ft.	
Wilson Fork Coal.....	36 inches.
Interval, 12 ft.	
Whitesburgh Coal	30 inches.
Interval, 70 ft.	
Big Branch Coal	24 inches.
Interval, 58 ft.	
Roundbottom Coal	24 inches.
Interval, 30 ft.	
Elkhorn Coal	24 inches.

Except on the head of Quicksand creek, on Middle and Laurel forks, where the strata dip southeast at the rate of about 16 feet per thousand feet, the beds are practically horizontal. The quantity of recoverable coal in the region is estimated as 936,000,000 tons.

8. *Beattyville Coal Area.*—A partial examination of the Beattyville coal area was also made by Mr. Fohs. This coal (ranging from 10 to 50 inches in thickness, with an average of 36 inches) underlies more than half of Lee county. The following interesting statement has been presented by Mr. Fohs: "Bells account for the local thinning of the coal, and are of two types: (a) gondola-shaped, 6 to 15 feet wide and 20 feet long, and (b) large, flat-boat-shaped, up to 100 feet wide and 1,000 feet long. Both types have nearly an east-west strike, so that a north-south cross-cut would usually pass through the thin coal with the least expense. The bed is also subject to rise and fall due to bending of the strata, but this is independent of the thinning of the coal; the small folds appear every 400 to 800 feet and have a general north-northwest trend."

9. *Oil and Gas.*—Considerable work was done in the study of oil and gas possibilities in several parts of the State. In the progress of the work in the area drained by the Quicksand creeks, favorable structure was found in Yellow Mountain, at the head of the Laurel fork of Quicksand, in Floyd and Knott counties. The mountain represents an anticlinal fold striking north-northeast, the west limb of which, according to Mr. Fohs, has a dip of 16 feet per 1,000 feet, while the dip of the east limb is still greater. The elevation of the Elkhorn coal at the head of Laurel is about 1,097 feet, while, according to Crandall, in the valley to the east, at the Jones fork of Right Beaver, it has dropped to 700 feet. In Lewis and Rowan counties two monoclinical folds occur. The following note on the folds has been presented by Mr. Fohs, in whose hands the study of the geology of the counties was placed: "One of the folds passes southward from just west of Carrs, east of Ribolt, Tolesboro, and Burtonville, and strikes N. 37 degrees E.; the first likely oil or gas horizon here would be the Lexington limestone. Further east is the northward extension of the Ragland monocline, which passes between Farmers and Free-stone, near Munson, between Stricklett and Awe, just east of Randville, and one mile east of Vanceburg. This monocline strikes N. 24 degrees E., and, with the surface rock Waverly, offers a number of good horizons at which oil or gas may have accumulated—notably, the Corniferous, Clinton, and Lexington formations." Investigations were made along the Rough

Creek anticline and in the Diamond Springs belt, in Western Kentucky, by J. H. Gardner and K. D. White, assisted by Lucian Walker. The Rough Creek anticline is a disturbance that stretches quite across the Western Coalfield and probably forms part of a line of disturbance that extends in a variable approximately east-west course across the State. It is believed that the work of the Survey will render it possible to avoid errors that have hitherto been made in locating points for drilling along the anticline. As the result of his studies of the region crossed by the uplift in Ohio county, Dr. Gardner advised drilling a deep well where favorable structure was noted by him, and such a well is going down. On January 4, 1912, oil was struck at 370 feet, and in such quantity as to give promise of a good productive well. In the course of his work in Webster county, very favorable structure, in the form of an elongated dome just south of Sebree, was discovered by Dr. Glenn. Dr. Glenn's description of the dome is given in the abstract from his report included in this report. To Mr. White was assigned the task of carefully working out the details of the dome, by means of an instrumental survey and the preparation of a contour map of the structure, and this he has performed in an excellent way. His report (Oil and Gas Prospect of the Rough Creek Anticline at Sebree) is ready for publication. A contour map of the structure of the Diamond Springs district, in Logan county, has also been made by Mr. White, the stratigraphy being worked out largely by Dr. Gardner. The work there has shown that the failure of some of the wells that had been drilled may be accounted for, if in no other way, by the fact that they were not properly located with reference to the structure as determined by the Survey. The report on the Diamond Springs belt, with accompanying structure map, is nearing completion. In co-operation with the U. S. Geological Survey, investigations were also made in Wayne, Powell, Wolfe, and Menefee counties. A report on the Wayne county field, by M. J. Munn, of the Federal Survey, who had charge of the work, is expected to be ready for publication by about the middle of February. A report on oil and gas in the Central City, Madisonville, Colhonnave and Newberg quadrangles, by F. M. Hutchison, is ready for publication.

10. *Mapping the Elm Lick Coal.*—One of the most important pieces of work undertaken in 1911 was the tracing and mapping of the outcrop of the Elm Lick coal in Ohio and Butler counties, with connections in Daviess. This work owes its importance chiefly to the fact that a key has thus been obtained for the solution of some difficult problems in connection with occurrences of coal in the eastern part and along the eastern margin of the Western Coalfield that for years have given trouble to persons interested in the mining industry. The work was placed in the hands of J. H. Gardner and K. D. White, who were assisted by Lucian Walker. The mapping began at Horton (formerly Elm Lick), in Ohio county. In a brief memorandum concerning the work, Dr. Gardner states: "Our first problem was to trace this coal bed, which had been noted and named by you in an early report, from Horton southeastward toward Butler county. We were able to follow the continuous outcrop of this bed to Morgantown, in Butler county, and to positively connect it with the coal bed which is being mined at Aberdeen. This was a contribution to knowledge and rather surprising in correlation. It affords a key to map the geology of Butler county and adjacent regions on the new topographic sheets which are being prepared in that section of the State. . . . While at Morgantown, we visited the Mud River mine in Muhlenberg county, and were of the opinion that the coal mined there is the same as the Elm Lick, in position." Returning to Horton the party traced and mapped the coal northward until it thinned out north of the Rough Creek Uplift. It had been supposed that the Elm Lick would correlate with the Deane field coal, but Dr. Gardner reports; "We proved that it is not the same as the Deane field coal, which extends into Daviess county, but that the latter is the next lower bed named the Hamlin coal in my section of Ohio county. The Elm Lick coal as traced over the territory outlined is very irregular in character, and will average less than 3 feet in thickness, very rarely approaching 4 feet. It is, however, an important reserve supply in the coal resources of West Kentucky." The mapping was done by Mr. White; the stratigraphy by Dr. Gardner. As the coal was traced southward marked evidences of erosion and unconformity were noted at the horizon of the bed, as had long been known to occur at

the horizon of the Aberdeen coal. Mr. White has correlated the Elm Lick with the "No. 5" coal as identified south of Sebree, in Webster county, by Dr. Glenn. If this be correct, it places the Elm Lick coal near the top of the Tradewater formation (a formation unit proposed by Dr. Glenn), where there is also a marked unconformity. The writer understands that from fossil evidence submitted to him, Mr. David White, of the U. S. Geological Survey, assigns the Elm Lick coal to Pottsville age.

11. *Field work on the Henderson quadrangle* was begun in 1911. The area has not been completely mapped, and the geological work is difficult because of lack of outcrops.

12. *Along Transportation Lines.*—Field work for a series of short reports on the economic resources adjacent to the railroad lines of the State was entered upon in 1911. The work was completed along the lines in the Jackson's Purchase region, to which Dr. Gardner was assigned; along the Louisville & Nashville railroad, from Louisville southward to the Tennessee boundary, to which Mr. Fohs was assigned; and along part of the Chesapeake & Ohio railroad. The report on the line of the Louisville & Nashville railroad has been prepared. This work has revealed the presence of greater values in economic resources along that line than had been known. Three short abstracts from the report of Mr. Fohs—on the Bowling Green stone industry, on honestone for marble in Hardin county, and on onyx-marble—have been prepared for publication in leaflet form. The report on the lines in the Purchase region is yet to be completed. Continuation of this work until all the railroad lines of the State have been traversed is one of the plans of the Survey.

13. *The Dix River Drainage and Water Power.*—The value of the Dix river as a source of water power was investigated in 1910-11. The drainage basin embraces an area of about 432 square miles, in Boyle, Garrard, Mercer, Lincoln, and Rockcastle counties. The economic resources of the region were also noted. The work was placed in the hands of Dr. August F. Foerste. The report has been turned over to the printer and is expected to come from the press within about four months.

14. *Phosphate Rock.*—The rock phosphate deposits of

central Kentucky were investigated by Dr. Foerste in 1911. A surprisingly large area of available commercial phosphate was determined. The report is in the hands of the printer.

15. *Clay Deposits.*—Investigations of the clay deposits has been continued, and much matter for an additional bulletin on clays has been gathered. The excellent plastic fireclay of Rockcastle county occurs at the horizon of the New Livingston coal, in beds each 4 feet to 6 feet in thickness above and below the coal where the latter is thin. The more notable occurrences are in the region between Mt. Vernon and Pine Hill, and south and southeast of the latter place. In his report on the county, Mr. Fohs estimates that in the region indicated there are about 3,800 acres of the clay, and that if the average thickness, exclusive of the 8 to 10-inch coal, be taken as 6 feet, there are over 11,000,000 tons of the clay. Technologic tests of very many carefully collected samples of clay, from various parts of the State, have been made by H. D. Easton, and a report of the work that has been done is nearing completion.

16. *Stone for Structural and Other Purposes.*—Reference has been made to the occurrences of valuable deposits of stone for various purposes in Rowan, Lewis, and Rockcastle counties, and in the region adjacent to the line of the Louisville & Nashville railroad, as noted in the reports of Mr. Fohs that have been prepared within the period covered by this report. It is believed that brief notes concerning them, given here, will prove useful: *Kentucky freestone* or "*bluestone*," a high class building stone, occurs at two horizons in the Waverly group—one in the Buena Vista beds at the base of the Cuyahoga formation, and the other (the Hummel bed of Rockcastle county) just above the Cuyahoga, in the upper Waverly. The first offers excellent quarry locations in Lewis and Rowan counties, and the stone is being quarried between Morehead and Farmers, adjacent to the Chesapeake & Ohio railroad. The stone occurs in beds 16 to 30 inches in thickness, three or four of which grade as of first quality and a number as of second quality. The Hummel bed has an average net thickness of 6 feet, and presents an accessible outcrop line of about five miles between Langford and Wildie in Rockcastle county—offering over 15,000,000 cubic feet of stone if a quarry width of only 100 feet be counted. *Oolitic limestones* are receiving much at-

tention. From two to four oolitic beds of excellent quality have been found to occur in the Ste. Genevieve-St. Louis formation on both sides of the Cincinnati geanticline. A systematic sampling of this series of limestones in Rockcastle county was accomplished, and beds adapted to nearly all purposes for which limestone may be used were found. The most important of the beds are the Sparks or upper oolitic bed, 10 to 31 feet thick, and the Mt. Vernon or lower bed, of similar character, 8 to 17 feet thick. Either of them is excellent for building stone, open hearth flux, etc. These limestones are found presenting an outcrop line of about twelve miles adjacent to the Louisville-Norton branch of the Louisville & Nashville railroad, between Maretburg and Sinks. In Hardin county, three miles southeast of Elizabethtown, a deposit of fine white oolitic limestone, 12 feet thick, was noted, which is twelve miles nearer to Louisville and eastern markets than is the Bedford stone. Excellent beds were also seen in the vicinity of Upton, adjacent to the railroad, and also at Horse Cave and at Cave City. The beds reach their greatest development in the Bowling Green region, where, instead of one quarryable bed, there are four, each showing a thickness of from 10 to 16 feet of net, massive, oolitic limestone. In this region four areas, easily accessible to river and rail, offer, under very little cover, approximately 128,000,000 cubic feet of excellent building stone. One of the beds, newly opened, is an unusually beautiful white oolite, readily carved and yet of good strength. These oolitic limestones are quarried at a cost of 15 cents per cubic foot and bring in the rough from 30 to 65 cents. *Veined decorative marbles*, suitable for interior purposes, in yellow, pink, and gray colors, occur in the Bowling Green region and in the vicinity of Cave City; they are to be had in beds from 3 to 15 feet in thickness. *Onyx-marble*, worthy of exploitation, is offered by the hundreds of caves in the Cave City and Glasgow Junction region. The good stone has an average value of \$3.00 per cubic foot undressed, and costs only \$1.15 to produce. A *honestone for marble*, an unusually fine-graded, porous, crystalline magnesian limestone bed occurs in the St. Louis formation in Hardin county. It is one of the two American "marble honestone" deposits marketed, and should find an extended use in pulverized form for polishing soft metals; and it

should replace the harder, merely scratching volcanic dust now used in household cleaners and in scouring soaps.

17. *Material for a Miscellaneous Bulletin* has been prepared. It includes notes on occurrences of asphalt rock in various parts of the State; on the different forms of calcium carbonate for making whiting; on the properties and applications of calcite whiting; on the great calcite vein in Mercer county and other similar deposits; on lithographic stone; on building stones; on the zinc rocks of Lewis county; and on some of the special sorts of calcareous stones of the State.

18. *Barytes Deposits*.—Study of the barytes deposits of central Kentucky has been completed and the report is nearing completion. This work is in the hands of F. Julius Fohs. The Survey has proved this to be the greatest barytes district in the United States. The available tonnage is enormous. There are near to 150 veins. The veins frequently have a linear extent of three and five miles, the average length being one mile, and the workable barytes extends to an average depth of about 250 feet. Until the Survey undertook this investigation, comparatively little was known concerning the value of our barytes deposits; indeed, Kentucky was not even mentioned as a source of commercial barytes in publications dealing with the mineral. Some mining was done years ago in one of the veins in Henry and Owen counties, and in Franklin county, but it was solely for the purpose of obtaining lead, and results were not, upon the whole, remunerative. Mining primarily for the barytes, with lead and zinc as a by-product, is now carried on in a number of localities. Two plants for preparing the mineral for market are in operation, and there is reason to expect that an additional one will be built at an early day. The writer believes that these are merely the pioneers of what will eventually prove to be a great Kentucky industry founded on these deposits.

19. *Calcite Deposits*.—Investigations of the calcite deposits were carried on co-incident with the work on barytes. As one result of the investigation a profitable industry, in the production of a very high grade of calcite whiting, has been established.

20. *Soil Work*.—Soil surveys were made in Webster, Ohio, Madison, and Rockcastle counties in 1910, and in the

Big Sandy Valley, in Henderson county, in Leslie county, and in Perry county in 1911. This work, which is in the hands of S. C. Jones, is carried along lines that are of real, practical value to the farmer. The field work is conducted by the Survey alone and the laboratory work (including pot culture experiments) by the Survey and the State Agricultural Experiment Station in cooperation. A valuable preliminary report of the results of his investigations during the past two years has been prepared by Mr. Jones, for this report, but it is thought best to present it as a separate. A brief statement concerning the soils and agricultural possibilities of the Eastern Coalfield, prepared by Mr. Jones and based on his work in that field during the past season, is included in this report in the hope that its early publication may prove helpful to those who are interested in the agricultural aspects of that rapidly advancing region.

21. *Soil Bulletin*.—Material for a Soil Bulletin has been prepared. It includes reports and papers as follows: The geology of Kentucky soils; a practical way to supply plant food to our soils; soils of the St. Louis and Chester formations as represented in Meade and Breckenridge counties; soils of the St. Louis and Waverly formations as represented in Adair, Green, and Taylor counties; ground limestone for improving soils; soil survey of the Marrs farm in Henderson, a study of the character and needs of certain sorts of defective farmlands in the Western Coalfield; effect of ground rock phosphate on Kentucky soils; soils of the Hartford quadrangle; soils of Rockcastle county; soils of the Webster county area; a study of soil types in Madison county; and the phosphate rocks of central Kentucky.

22. *Chemical Work*.—Several hundred analyses have been made in the chemical laboratory of the Survey. The samples analyzed include not only those collected by the Survey, but a great number that have been sent in by citizens throughout the State. No charge is made for analytical work done for citizens of the State, and every effort is made to furnish results within a short time. Unfortunately, however, the chemist (whose hands are always full) can not always analyse the samples sent in as soon as the persons sending them de-

sire, and this has caused the Director to receive some unpleasant communications in regard to the matter.

TOPOGRAPHIC MAPPING.

Mapping of the State, which is being carried on in cooperation with the U. S. Geological Survey, is being pushed as rapidly as possible. Each organization bears half of the expenses of field and office work. For the \$10,000 per annum expended by Kentucky the State receives more than \$20,000 in the way of results, since the Federal Survey engraves and prints the maps without cost to the State. The mapping is done according to quadrangles, each of which includes an area (varying according to location) of about 238 square miles.

In the Eastern Coalfield, where accurate contour maps are greatly needed—are, indeed, absolutely required before detailed geology (such as mapping the outcrop lines, and thus determining the areas, of important coals) can be taken up properly—much time has been consumed in making the triangulation and running primary levels and traverse necessary before the final topographic work can be undertaken. A large portion of the field, together with an area which includes Lewis and Rowan counties, has been triangulated and primary "control" obtained, and detailed topographic work has been taken up. In the Western Coalfield the obtention of preliminary control is less difficult than in the more rugged Eastern one, and more rapid progress has been made in completing topographic sheets. Several quadrangles outside the coal fields have been surveyed, and the sheets published, but it has seemed best at this time to place most of the mapping in the coal fields and the oil and gas fields, where accurate maps are indispensable for accurate geologic work. About twenty maps made in cooperation have been published.

The field work for the following quadrangles has been completed within the last two years: The Nortonville, including parts of Muhlenberg, Hopkins, and Christian counties, area 238 square miles (map published); the Drakesboro, including parts of Muhlenberg, Todd and Logan, area 238 square miles; the Berrys Lick or Rochester, including parts of Muhlenberg, Ohio, Logan, and Butler, area 238 square miles; the Little

Muddy or Morgantown, including parts of Butler, Warren, and Logan, area mapped 171 square miles (nearly completed); the Monticello, including parts of Wayne, Russell, and Clinton, area mapped 108 square miles (completed); the Crockettville, including parts of Breathitt, Perry, and Leslie, area 237 square miles; the Troublesome, including parts of Breathitt, Perry, and Knott, area 237 square miles. Such field work was done in the Lagrange and Taylorsville quadrangles as was necessary to complete the map of Jefferson county. In the course of the work, as reported by the director of the U. S. Geological Survey, 1,555 square miles were mapped; 514 miles of primary levels were run; 152 permanent bench marks were set; and 5,533 miles of secondary traverse were run. To this must be added the areas covered by triangulation.

The topographic mapping is carried on under the supervision of W. H. Herron, Geographer in charge of the Central Division of the U. S. Geological Survey. An account explaining in detail cooperative methods of topographic surveys and the results of primary leveling, triangulation, and primary traverse, during the past two seasons, together with an index map of Kentucky, has been prepared by Mr. Herron; this will be presented for publication as a separate.

PUBLICATION OF REPORTS.

The Survey has been greatly embarrassed in its work through failure to get its reports printed within reasonable time—a matter quite beyond the control of the Director. Attention was called to this in the last Biennial report. Delays on the part of contractors for public printing have not only held up the publication of reports long after their preparation, but they have subjected the Survey to criticism that it has not in any way deserved; moreover, these delays have compelled the Director to give much time to the preparation of special matter relating to regions inquired about, to meet the requirements of correspondence, that should have been available for other matters, including field work. An accumulation of unprinted reports has resulted from such delays, but it is now hoped that, in consequence of arrangements that have been made recently by the Superintendent of Public Printing, the accumulated re-

ports will go through the press within the next four months, and that reports now in course of preparation will be published within proper time.

To in some degree compensate for delays in printing the complete reports, it is proposed to hereafter issue leaflets and press letters from time to time, to such extent as the resources of the Survey will permit and the Governor approve.

Following is a memorandum of reports in the hands of printers, reports ready for publication but reserved, and reports in course of preparation:

In the Hands of Printers.

No. 16. Bulletin 13. The coals of the Poor and Clover Forks of Cumberland River in Harlan and Letcher counties. By J. M. Hodge. (In printer's hands since July 31, 1911.)

No. 17. Bulletin 14. Coals of the Pineville Gap Region in Knox and Bell counties. Includes the Log Mountains, Yellow and Browning Creeks, Straight Creek and its branches, Stewarts Branch, and Fourmile Creek in Bell; and Greasy, Brush, and Stinking Creeks in Knox. By G. M. Sullivan and A. R. Crandall. (In printer's hands since July 31, 1911.)

No. 18. County Report 1. The mineral veins and other resources of Livingston county. By R. H. Loughridge; revisions up to 1910 by F. J. Fohs. This report, with three others was lost after it had been placed in the hands of a former contractor for public printing. Reproduced in 1910-11.

No. 19. Bulletin 15. General Report on the Lead, Zinc, Fluorspar, Barytes, and Calcspar Region of Western Kentucky, in Caldwell, Crittenden, Christian, Livingston, Lyon, and Trigg Counties. By F. J. Fohs. This report was lost after it had been placed in the hands of a former contractor for public printing. Reproduced in 1910-11.

No. 20. County Report 2. Geology and Soils of Adair, Green, and Taylor Counties. Geology by A. M. Miller. Soils by S. C. Jones. (Ready since 1909.)

No. 21. Bulletin 16. The Waverly Formations of East Central Kentucky, and their Economic Values, in Lewis, Greenup, Carter, Rowan, Bath, Menefee, Montgomery, Powell, Morgan, Estill, Fleming, and Clark Counties. By W. C. Morse and A. F. Foerste. (Ready since December, 1909.)

No. 22. County Report 3. Report on the Economic Re-

sources of Lewis and Rowan Counties. By F. J. Fohs. (Ready since 1910.)

No. 23. County Report 4. Report on the Economic Resources and Soils of Rockcastle County. Geology by F. J. Fohs. Soils by S. C. Jones. (Ready since 1910.)

No. 24. Bulletin 17. Geological Reconnaissance of the Region Drained by the Tradewater River, with special reference to coals. Embraces parts of Union, Webster, Hopkins, Christian, Crittenden, and Caldwell counties. By L. C. Glenn. (Ready since 1910.)

No. 25. Bulletin 18. Coals of the Region Drained by the Quicksand Creeks, in Breathitt, Floyd, and Knott Counties. By F. J. Fohs. (Ready in 1911.)

No. 27. Bulletin 20. Preliminary Report on the Economic Geology of the Hartford Quadrangle, together with a report on the soils. Geology by J. H. Gardner. Soils by S. C. Jones. (Made ready in 1911.)

No. 28. Bulletin 21. The Value of Dix River as a Source of Water Power. By A. F. Foerste. (Made ready in 1911.)

No. 29. Bulletin 22. Geology of the Central City, Madisonville, Calhoun, and Newberg Quadrangles, in Muhlenberg, Ohio, Hopkins, McLean, Webster, Daviess, and Henderson Counties. By F. M. Hutchinson. Four reports in one Bulletin. (Made ready in 1911.)

Ready for Publication But Reserved.

The following are reserved until progress is made on other reports now in the hands of printers, or for other reasons given:

No. 26. Bulletin 19. General Account of the Natural Resources of Kentucky. (It is desired to use some of the plates that have been prepared for reports already noted.)

No. 14. Bulletin 8. Key to the State Geological Map. (This has been ready so long that, since it is desired to get out a new edition of the map, it is held for revision to suit such map. If a new map cannot be issued, the Key will be printed as it now stands.)

No. 30. Bulletin 23. Soil Bulletin. (In cooperation with State Agricultural Experiment Station.) The contents of this Bulletin have been given in paragraph 22 on a preceding page.

No. 31. Bulletin 24. Miscellaneous. The contents of this Bulletin have been given in paragraph 17 on a preceding page.

Reports in Course of Preparation.

1. Commercial Values of Kentucky Clays, as Determined by Kiln Tests and Otherwise, from Various Parts of Kentucky. By H. D. Easton. (This Bulletin, nearing completion, is the result of a long series of technologic tests by Prof. Easton.)

2. The Soils and Agricultural Conditions of the Big Sandy Valley. By S. C. Jones.

3. Study of a Typical Area of Mountain Soils in the Region Drained by the Three Forks of the Kentucky River, as Represented by Perry and Leslie Counties, with a Discussion of the Agricultural Possibilities of that Region. By S. C. Jones.

4. A General Discussion of the Soils of Kentucky. By S. C. Jones.

5. A General Discussion of the Coals of the Eastern and Western Fields, with analyses and determinations of calorific values. By C. J. Norwood.

6. The Barytes Deposit of Kentucky. By F. J. Fohs.

7. The Coals and Other Resources of Webster County, an area representative of varied structural conditions encountered in the Western Coalfield. By L. C. Glenn.

8. Oil and Gas Bulletin No. 2. Includes: Oil and gas along the Rough Creek Anticline, in Ohio county, by J. H. Gardner; the Diamond Springs Oil and Gas District, by J. H. Gardner and K. D. White; the Sebree Dome as a Possible Source of Oil and Gas, by K. D. White (ready); Errors that Have Been Made in Drilling Along the Rough Creek Anticline, by K. D. White; Oil and Gas in the Central City, Calhoun, and Madisonville quadrangle, by F. M. Hutchinson (ready).

9. The Phosphate Rocks of the Midway District. By A. F. Foerste.

10. A General Account of the Structural Materials of Kentucky. By C. J. Norwood.

11. Study of the Elm Lick Coal and Its Outcrop Line. Stratigraphy by J. H. Gardner; map by K. D. White.

12. Study of the Wayne County Oil District, with Some

Notes on Other Kentucky Fields, by M. J. Mund. (In co-operation with the U. S. Geological Survey.)

13. Bulletin on Resources Along Transportation Lines. Includes: (a) Along the Louisville & Nashville Railroad, from Louisville to the Tennessee Line, by F. J. Fohs. Is ready. (b) Along the Railroad Lines in the Jackson's Purchase Region, by J. H. Gardner.

PROJECTED WORK.

Projected work includes continuation of investigations in the coal fields; continuation of work along transportation lines, and of investigations of clays in field and testing laboratory; investigation of mine gases and dusts; study of the streams, including, if it can be arranged, co-operation with the State Board of Health in the study of stream pollution; investigations of materials for road-building, and of structural materials, including stone, cement rock, and sands; and continuation of the oil and gas surveys, of the soil surveys, and of topographic mapping. Such county work will be taken up within the ensuing season as conditions will permit.

DISBURSEMENTS.

The Survey is credited with its appropriations according to fiscal years ending June 30th, but the Director's reports of expenditures are required to be checked with the Auditor's books according to quarters of the calendar year. The following report of expenditures, showing "amounts expended, under proper heads, and for what purpose," is therefore, made up according to calendar years.

DISBURSEMENTS CALENDAR YEAR 1910.

Geology, including oil and gas surveys.	
Salaries	\$4,908.01
Field and allied expenses.....	1,388.74
Total	\$6,296.75
Soil Investigations.	
Salaries (exclusive of geologists).....	\$1,179.98
Field expenses	398.16
Total	\$1,578.14

Chemistry and Chemical Laboratory.	
Salaries	\$1,800.00
Apparatus and Supplies	403.71
Total	\$2,203.71
Technology of Clays.	
Salaries	600.00
Fuel Testing.	
Salaries	\$150.00
Office.	
Salaries (clerk, stenographer, and janitor).....	\$1,680.00
Supplies, postage, telegrams, telephone, P. O. box rent.	113.24
	\$1,798.24
Drafting.	
Salary	\$1,200.00
Museum.	
Temporary aid at various times, labor at various times, repairs to cases, and supplies (soap, mops, etc.)....	\$211.20
Equipment and Repairs and General Supplies.	
Repairs to barometers, multigraph, tables.....	\$363.70
Freight, cartage, and expressage.....	\$84.31
Director.	
Pay at \$25 per month.....	\$300.00
Traveling expenses	19.32
	\$319.32
Co-operative Mapping.	
Salaries, subsistence, and miscellaneous field expenses	\$6,530.79

DISBURSEMENTS CALENDAR YEAR 1911.

Geology, Including Oil and Gas.	
Salaries	\$6,055.65
Field and allied expenses.....	1,645.19
Total	\$7,700.84
Soil Investigations.	
Salaries	\$1,196.97
Field expenses	363.92
Total	\$1,560.89

Chemistry and Chemical Laboratory.	
Salaries	\$1,800.00
Supplies and apparatus	141.64
Total	\$1,941.64
Technology of Clays.	
Salaries	\$600.00
Fuel Testing.	
Salary	\$25.00
Stream Gaging.	
Pay of gager, 6 months	\$48.00
Office.	
Salaries (clerk, stenographer, janitor, and temporary aid)	\$1,815.00
Supplies, postage, P. O. box, telephone, telegrams.....	123.65
Total	\$1,938.65
Collecting Mineral Statistics in co-operation with U. S. Geo. Survey.	
Pay of aid	\$225.00
Drafting.	
Salary	\$1,200.00
Museum.	
Repairs to cases, molding for hanging pictures, labor at various times, supplies	\$134.20
Equipment, Repairs and General Supplies.	
Repairing transit, adjusting typewriter, field books, drawing paper, tracing cloth, blue-print papers, oil for clay kiln, window shades, drawing ink, and similar items	\$114.43
Freights, cartage, and expressage.....	\$45.81
Director.	
Pay at \$25 per month	\$300.00
Traveling expenses	41.88
Total	\$341.88
Charged Against the Survey by error of Auditor's Office.	
Engraving and printing maps for Bulletin 12	\$91.00
Printing blanks for Inspector of Mines.....	9.46
Total	\$100.46
Mapping in Co-operation with U. S. Geo. Survey.	
Salaries, subsistence, and miscellaneous field expenses.	\$13,441.71

THE GEOLOGY OF WEBSTER COUNTY.

Abstracts from Report of L. C. Glenn.

(It is due Dr. Glenn that it should be said he prepared a very full abstract of the first part of his report for this Biennial Report. It has seemed best, however, to keep this report within narrower limits than would be possible were the complete abstract used. Therefore, only those parts of his abstract that deal with Stratigraphy, Structure, and Economic Geology are inserted here. The part relating to stratigraphy has been condensed, and some minor matter relating to structure ("Minor Folds and Faults") has been summed up in a few words, but the part relating to economic resources is given in full, as written by Dr. Glenn.—C. J. N.)

Webster county lies wholly within the coal field of Western Kentucky. It is north of Hopkins and immediately south of Union and Henderson counties. The Rough Creek anticline, which crosses northern Webster, and the Webster synclinal basin, farther south, affect the depth of the coal beds so that near the former they may occur in outcrop or at shallow depths, while to the southwestward, near the center of the basin, some of the coals lie at depths at present too great for them to be mined.

STRATIGRAPHY.

It is important to note in the subjoined section that the workable coals, the chief economic resource of the county, are confined to the Tradewater formation, which includes the Bell and "No. 5" coals, and to the Mulford formation, which carries the "No. 9," "No. 11," and "No. 12" beds. It is also important to note the unconformities which locally affect the Baker, the "No. 9," and the "No. 11" coals.

General Section.

Recent:	Feet.
Alluvium deposits along stream beds.	
Pleistocene.	
Graves Creek formation: Fine or mucky clay and sand gravel	100-175
Pliocene.	
Union formation: Yellowish or brownish loam, locally a typical loess (with land shells).....	8-20
Lafayette formation: Chert and quartz gravels cemented by ironstone crusts; provisionally correlated; a few feet.	
Marked unconformity; formations above frequently absent.	
Pennsylvanian Series.	
Dixon formation: Calcareous shale containing a 20-foot limestone bed constitutes the upper 150 to 250 feet. Vandersburg sandstone, fine-grained and of variable character, possibly 25 feet. Shales 80 to 100 feet. Dixon sandstone, fine-grained and of variable character, 10 to 25 feet; rarely 50 to 60 feet. Total thickness, with thin coals of no present value, about	340
Unconformity.	
Lisman formation: Chiefly soft shale, sometimes colored and calcareous, with some sandstone and thin limestones (including the Madisonville limestone), with the Anvil Rock sandstone—ferruginous coarse to conglomeritic and cross-bedded—10 to 55 feet thick, usually at the base, but absent between Clay and Wheatcroft, where shale containing the Baker coal forms the base. Total thickness.....	900-1000
Marked unconformity. Possibly responsible for the presence or absence of the Baker coal.	
Mulford formation: Chiefly shale, but contains important coals. Beginning at top: Shale 10 to 30 feet (rarely 125 to 150 feet) with a thin limestone at the base. <i>Unconformity</i> , which causes absence of No. 11 coal; in the Clay and Sebree regions. No 11 coal; shale except in southwestern Webster, where a prominent sandstone occurs near the base, 90 to	

100 feet. <i>Unconformity</i> , responsible locally for the absence of 20 to 30 feet of shale and the occasional cutting of channels 50 to 75 yards across into No. 9 coal. Total thickness, 250 feet (east of Providence) and 146 feet (at Sebree); usually.....	150
DeKoven formation: Shales, thin sandstones, and thin (unworkable) coals. At the base is the Sebree sandstone, coarse and massive, 10 to 50 feet thick. Formation is of variable thickness—100 feet in the Sullivan-Providence region, thickening to 151 feet at Sebree, and to 398 feet further north, at Tilden. Thickness	100-400
Marked unconformity.	
Tradewater formation: Principally shale with occasional inconstant sandstone beds. Includes No. 5 coal near top and the Bell coal near the base. Thickens from 175 feet at Sebree, in eastern Webster, to 700 feet in western Union and western Webster. Thickness	175-700
Caseyville formation: Coarse, cross-bedded, conglomeritic, cliff-forming sandstones in 20-foot to 60-foot beds alternating with thin beds of shale (up to 20 feet thick), containing thin (usually valueless) coal seams. Thickness, about	200
Marked unconformity.	
Mississippian Series.	
Lockhart-Leitchfield formations: Fine grained fossiliferous limestones and fine-grained quartzitic sandstones. Exposed	200

Beneath the Lockhart-Leitchfield formations are lower-lying Mississippian limestones, sandstones, and shales; Devonian shale; and Silurian rocks, the coarsely porous beds of which, under suitable structural conditions, may yield oil and gas.

The surface of the county is a succession of lowlands and uplands, with the former predominating. At the southwestern margin of the county, along Tradewater river, is a narrow strip of lowland underlain by the Tradewater formation and bordered on the northeast by an upland belt of three parallel ridges of harder rock. Near the base of the first ridge, which is characterized by the upper Tradewater and DeKoven formations, is the No. 5 coal, while the second ridge, characterized by

the Mulford formation, has the No. 9 coal at its base. Coal No. 11 is near the base of the third ridge. These three sandstone-capped ridges run southeastward across the county, from near Sullivan or Wheateroft to Providence and beyond. Next is a lawland trending northeast across the county, several miles wide between Clay and Lisman; it is characterized by the Lisman formation and Baker coal. Northeastward, a broad upland belt crosses the center of the county and includes the towns of Dixon and Vandersburg; it is characterized by the Dixon formation. Belcourt and Outon are on a subordinate upland containing a coal of local value, while the Sebree upland extends from Marks-ville eastward to Green river, showing outcrops, both north and south, of coals No. 9, No. 11, and No. 12; the latter also underlie nearly all of the lowland occupied by Green river and its tributaries. Still another upland, of moderate relief, stretches across the northern end of the county. These uplands are separated by Deer creek, Graves creek and the Green river. Between the Dixon and Sebree uplands is the Rough creek uplift, along whose course the Lockhart-Leitchfield, the Caseyville, and higher formations are exposed.

The relationship of lowland and upland belts to the coals and formations here described should prove a helpful guide in the location of coal beds.

STRUCTURE.

The general or broad structural features of the county are simple. The rocks of all the county, except a strip a few miles wide east and west across its northern end, lie in a broad synclinal trough. The axis of this trough has a general north-west-southeast course and it runs roughly through the Luzon-Dixon-Mt. Gilead school region, coinciding in a general way with the axial line of the Dixon upland.

From the Tradewater and beyond the rocks dip northeastward in this axial line at a rate that generally runs from two to four or five degrees. This dip is somewhat greater in the western part of the county, about Wheateroft and Clay, than farther east about Providence.

The axial position is not sharply compressed, but the bottom of the trough is broad and fairly flat. The trough is deeper in the Mt. Gilead region than in the Dixon region.

On the northeast the rocks dip southwestward generally at a somewhat higher angle, especially as one nears the Rough creek anticline, where dips of eight to twelve or fifteen degrees are not uncommon, while locally dips may go much higher, though high dips, when traceable in surface exposure, are found to flatten out very rapidly and hence do not involve a great thickness of rocks.

The northern edge of the structural basin passes east through Tilden, and the crest of the Fulcher and Melton hills and of the Sebree hills, or delimited by the Rough creek anticline. This basin might be called the Webster syncline, if a name for it became desirable.

The Sebree Anticline. On the northeast side of the broad basin above described, the rocks generally rise until they are broken sharply off by a fault line along the Rough creek anticline. From Marks-ville east to Green river, however, the rocks rise to an anticlinal crest and then pitch down on the north side before they are broken off by the great fault. They thus form a long, narrow anticline with the rocks strongly arched, but not badly crushed or broken along its axis. This anticline plunges down and dies out just north of Marks-ville at its west end. About a mile east or southeast of Sebree it also plunges down for some distance, but farther east the axis becomes horizontal again and it leaves the county at Steamport Ferry still as a pronounced anticline. The highest point along the axis of this anticline is in the hill about half a mile southwest of Sebree Springs, where the structure is somewhat domed. The elevation of this dome has been great enough to bring the top of the Caseyville conglomerate above drainage level there, where it forms the cliffs about Sebree Springs.

The Rough Creek Anticline. This disturbance enters the county on the Union county side near Givens and pursues a somewhat zig-zag course through Tilden, the Fulcher and Melton hills, the northern part of the Sebree hills, through Sebree to Green river about half a mile south of Eastwood ferry, where it passes into McLean county.

This faulting was caused by an overthrust from the south. In places the rocks broke and those from the south were thrust up over those on the north side of the fault. In other places the faulting was of the block type and small areas, always on

the south side of what may be considered the main line of faulting, were lifted bodily upward several hundred feet. The zig-zag course of the fault line across the county is due to the predominance of the block-fault feature. East of Marksville, as has been said above, the faulting has been attended with the development of an anticline on the south side of the general fault line, but even here there is also block faulting and crushing along the fault plane on the north side of this subordinate anticline. In Webster county the term *Rough creek fault* would be more applicable than *Rough creek anticline*.

North of this great fault line the rocks are essentially flat. They do dip to the northwest or west-northwest, but at a very low angle, and they seem to be practically undisturbed on their southern margin even up almost to the very fault plane itself.

(Elsewhere in his report Dr. Glenn calls attention to the fact that "along the Rough creek anticline rocks stratigraphically 2,500 feet or more apart may be found lying side by side. He also observes that minor folds and faults occur in the shales and other rocks, but that they are usually insignificant and unlikely to affect the economic value or workability of the important coal beds in any material way.—C. J. N.)

ECONOMIC GEOLOGY.

Coal is the only mineral resource at present developed. There are a number of seams of much economic importance in the county.

In the southwestern part of the county the lowest of these seams is not exposed at the surface, but may be reached by shaft along the Tradewater river in the general vicinity of Blackford. This seam is the Bell coal. Its thickness and quality are not known in Webster county, but its outcrop down the Tradewater makes it probable that workable areas may be found by boring in this county.

Coal No. 5 of Owen, now generally called No. 6, is workable along its outcrop practically across the entire southwestern end of the county. This outcrop is at or near the foot of the steep scarp overlooking the Tradewater lowland and runs, as has already been said in the topographic section of this report, from Sullivan to Yarbrow. This coal is mined for local use at sev-

eral country banks between Golds and Rice's mill. It is solid and about 46 inches in thickness. Over it there are 3 to 5 feet of black shale, separated from the coal by a highly calcareous layer three to six inches thick and filled with marine fossils. This is very characteristic of this coal in this region.

The dip of the rocks northwestward into the Webster synclinal basin soon carries this No. 5 coal too far below drainage to permit of its being worked at present, and when these rocks again rise to the surface in the Sebree region this coal has thinned until it is no longer workable, and, indeed, is not identified with perfect certainty, though it seems probable that it is the second thin coal beneath the Sebree sandstone there.

Coal No. 6, now generally called No. 7, lies close beneath the scarp-making Sebree sandstone. It is nowhere known to be thick enough to work in the southwestern part of the county, though attempts have been made to work it at several places southwest of Providence, where it is somewhat thicker than usual, but is very dirty and varies greatly in section in even a few yards. In the Sebree region it is most probably the coal that years ago was opened at country banks at a number of places in the hills two to three or four miles southwest of Sebree. It is characterized by its position close beneath the scarp of the Sebree sandstone and by being underlaid by 3 to 6 feet of gray siliceous fireclay filled with narrow strap-shaped plant impressions.

The next coal of value is No. 9. This is the most uniform in presence, thickness, and good quality of all the coals of the county and is, all in all, the most valuable one.

It is without parting, is very uniformly 56 to 58 inches thick, and has a massive black shale roof that everywhere contains concretions of iron sulphide or iron carbonate popularly known as "niggerheads."

The quality is good and this coal is actively mined on a commercial scale at numerous points on its southwestern outcrop, from Wheatcroft, or west of there, to Providence. In a broad area in the central part of the Webster synclinal basin this coal, as well as coals No. 11, No. 12, and No. 13 above it, are all too deep to be mined at present, though the day can not be far distant when it will become practicable to reach them by shaft.

On the northeast side of the basin, coal No. 9 rises to the surface near Marksville, where it is now mined at the Sparks or Woods mine, and has been mined at a number of places east of there in the vicinity of Ortiz.

North of the Rough creek anticline No. 9 coal is everywhere present in Webster county, except where the old deep valley of Green river has cut it out. It is mined by shaft at Sebree.

Ninety to a hundred feet over No. 9 is generally found another coal, No. 11, that is comparable to No. 9 in commercial value and is likewise extensively mined. No. 11 is, however, variable in thickness and liable to be found absent in places, so that it is not reliable a coal as No. 9. One intending to develop it should very thoroughly prospect the area with a core drill before purchase. This coal is absent for several miles along its outcrop horizon in the Clay neighborhood. The gap extends from the old Toga mine near Wheatcroft to near the Lever mine some two miles northwest of Providence.

In the Sebree region coal No. 11 is usually partly or entirely absent.

It is characterized most readily by lying close beneath a limestone that everywhere contains fusulinas. This coal also contains everywhere a band of clay, usually about two inches thick and known as the "blue band." The thickness will vary from 5 to 7 feet. Between the coal and the overlying limestone there may be some inches of black slate, or soft clay, or "gob." The limestone forms an excellent roof.

Coal No. 12 lies close above the limestone over No. 11 coal, but is rarely thick enough or regular enough in Webster county to be prospected. On the Frank Sanders place, two miles west of Sebree, it has been mined as a country bank. It is not generally regarded as a valuable coal. The Marks coal, mined at Marksville, belongs here. It is pockety in its development there.

Above coal No. 12 at a variable interval of, say, 20 to 40 or more feet, there is found in the region northwest of Clay a valuable coal called by the writer the Baker coal, or coal 13 in numerical order since it is the next coal above No. 12 coal in this region. It seems probable that it is the same as a similar thick and excellent coal known in the region east of Webster

county in a number of places and there sometimes called coal No. 14.

The hazard in giving numbers to coals that are but little known or can not easily be traced and identified stratigraphically is well illustrated by this Baker coal in its relationship to coal No. 11, the identity of which at any point is never in question. In a drill hole of the West Kentucky Coal Company in line with the slope entry of their Mine 4 at Wheatcroft, and 2,200 feet in advance of their workings in June 1910, the first coal above coal No. 11 was 56 feet higher, and it might, in the absence of other data, be called coal No. 12; but in another hole at the end of the slope entry, i. e., 2,200 feet from the first mentioned hole, this interval had decreased to 45 feet and another coal had appeared within it. Numbered here, this new intermediate coal would be No. 12, as it is, indeed, generally and properly known there, and the upper coal would be numbered thirteen, this upper one being the Baker coal. When such confusion in correlation may result from the presence or absence of a coal within less than half a mile, it is evident that something more than mere numerical sequence is necessary in correlating coals a score or more of miles apart, it may be. Where such widely separated coals are thin and little known and there is little or nothing distinctive about them or their stratigraphic setting, it is extremely hazardous to attempt numbering. This would apply especially to the thin coals in the top of the Lisman and in the Dixon formation. As these, however, are not of commercial or, except in rare small areas, even of local importance, it is not thought desirable in a brief summary such as this to attempt to name or describe them.

Oil and Gas.—The rocks that underlie Webster county are known to contain at least small quantities of oil and gas, and numerous attempts have been made, especially near Tilden and at Sebree, to develop an oil field. These attempts were all made on the north side of the Rough creek fault and were all in about as unfavorable places as could well have been selected. At these places small seeps of oil or gas occur, working their way up along the fault planes; and faults that permit the escape of oil and gas naturally, are not generally favorable places to drill for accumulations of oil or gas. The rocks on the south side of the fault rise northward up to the fault plane,

and if oil has accumulated at any point along the fault it would be in these tilted or dipping rocks on the south side of the fault plane, not in the flat rocks on the north side. The chances would have been greater for striking oil at Tilden if the wells had been drilled half a mile or a mile south of where they were drilled, though even there the chances could not be said to be very favorable.

A description is given in the structural section of this report of an anticline extending east from near Marksville, just south of Sebree, to Steamport Ferry and beyond, and a doming of this anticline was mentioned. This dome has its center about where the highway crosses the hill top a half mile southwest of Sebree Springs, or a few hundred yards east of this road crossing. This dome and the area along or close by on the north or south of the axis of the anticline for a mile or or possibly two miles east of there, and for a similar distance west of there, appear to be the most favorable territory in the county to prospect for oil and gas.

Another almost equally favorable area is the high hill crest near or east of the old McLarty place a mile west of Knob Lick creek, where a slight doming of the axis also occurs.

Shale and Clay.—There is an abundance of shale and clay almost everywhere for brick and tile making and such industries could be developed without limit.

Fireclay.—While tests have not been made, the underclays of several of the various coals, especially that under Owen's No. 6 coal, seem probably to be fireclays and would warrant experimental tests to determine their values.

Building Stone.—The sandstones of the county contain much material that might be used as building stone. The only quarry is the one two miles east of Sebree, where stone is gotten out for local use for foundations and chimneys.

The limestones are sometimes used for rough foundations, though generally little or no attention is paid to their use. They are probably too impure to be used for lime. They could be used to advantage for crushed stone for road building.

Sand.—Sand for local use may be obtained at numerous places along the streams in or at the edge of the uplands, but is absent from the lowlands. In some places the Dixon sand-

stone is disintegrated to a soft, loose mass used for building sand.

Miscellaneous.—In various places small pieces of galena, sphalerite, fluorite, phosphate, pyrite, and siderite may be found in place in the county, but nowhere is there any probability whatever that any of them occur in economically valuable quantities. There are also legends of silver mines supposed to exist, especially in the Sebree hills, and known to the Indians and certain ones of the early settlers. It is needless to say to any one who knows the mode of occurrence of silver that such stories are pure myths; and the most positive assurance may be given to credulous parties, who even now occasionally spend time and money hunting and digging for such mythical hidden wealth, that in such search both time and money are wasted.

SOILS AND AGRICULTURE OF THE EASTERN COALFIELD.

By S. C. Jones.

The area lying within the Eastern Coalfield that is generally referred to as the "Mountain Region of Kentucky" represents about one-fifth of the total area of the State, or about 8,000 square miles. It was long looked upon, by those ignorant of its possibilities, as a practically valueless country. In truth, it has been handicapped in the past because of its poor wagon-roads and the lack of railroads, which meant that it was practically shut off from the rest of the world.

But the hills and mountains of this region are rich in fine coals, which offer particular advantages for mining, and in some sections there are vast tracts clothed with valuable timbers. Now, the outside world is demanding both the coal and the timber; consequently many miles of railroad are now under construction, many new mines are being opened and

equipped, and towns are springing up where but a few months ago stood the silent forest. Coal lands that but a few years ago sold for fifty cents to two dollars an acre now bring from twenty dollars to one hundred dollars an acre. The whole "mountain region" is astir. It is doubtful whether there is to be found anywhere in the United States a section of country that is undergoing more rapid development, or one in which wealth is being created more rapidly than in this Eastern Coalfield of Kentucky.

While this section of the State is not what may be termed an agricultural country, the fact that its mining interests are being developed means also the development of conditions favorable for certain phases or types of agriculture.

The soils of the region are derived from sandstones, sandy shales, clays and coals that go to make up the Coal Measures. This soil area, like other great soil areas of the State, presents conditions conducive to diversified soils. They may be divided in a general way into three classes, namely: Those of the ridges, those of the hillsides, and those of the bottoms.

Over the greater portion of this area the ridges are too narrow for any purpose, while near the border of the Coalfield is found more or less ridge land covered with soils varying from sand to sandy loams, or loams underlain with a more clay-like subsoil.

On the hillsides are found loams, sandy loams, and shale or gravelly loams. The soils on the east and north hillsides (those facing the east and north), and those in the coves, are usually deeper than those on the south and west hillsides. The south and west hillsides are regarded better for grass, while the east and north hillsides are regarded better for cultivation.

It will be seen by observing the geological map of the State that streams are numerous in the Eastern Coalfield, along which is found more or less bottom land. The width of the bottoms vary of course with the size of the streams. Along many of the streams are found both first and second bottoms. The first bottom lies near the stream and is subject to overflow, while the second bottom is usually above the overflow line.

In the first bottoms brown sandy loams and loams are found, while in the second bottoms are found silt-loams, loams,

and clay loams of varying color, ranging from gray to yellow and brown. The gray soils are found in the wider bottoms near the base of the hill, and would be greatly benefited by artificial drainage. No doubt drainage would greatly benefit all of the second bottom soils.

The future for the soils of this section of the State lies in the development of ^{forestry} ~~property~~, horticulture, grazing, truck gardening, and the production of poultry.

There are large areas of rough sandy ~~loam~~ ^{land} in parts of this region that are fit only for forestry. Such areas are usually found along the dividing ridges between the main water ways. Many of these areas have already fallen into the hands of companies that are handling the forest with more or less care, while as a rule the forest belonging to the individual is being rapidly destroyed.

It is perhaps safe to say that there is a greater future for horticulture in Eastern Kentucky than for any other phase of agriculture. While it is true that the large fruits, such as apples, peaches, and pears, are often damaged by late freezes and frosts, yet if the proper varieties were grown and the orchards properly cared for no doubt this damage could be materially decreased. Grapes and other small fruits appear to do especially well when given attention.

On the hillsides containing the loamy soils or soils of more clay-like nature, and even on the sandy soils, such grasses as orchard grass, red top, English blue grass, and even Kentucky blue grass thrive well when given favorable opportunities. The great reason for failure in growing grass is that the land is corned to death before an attempt is made to produce grass. When sown in new land that has been well cared for, success usually results. Japanese clover grows wild and now is the chief grass for pasture.

Sheep will no doubt be the most profitable animal for this country, especially where the more important breeds take the place of the mountain sheep.

With the increase in the mining population the bottom lands will naturally be converted into truck gardens. Much of the bottom land has been cultivated in corn year after year for the last seventy-five or hundred years, and is now badly

worn, especially that lying above the overflow line. The overflow land is practically as fertile as when first cultivated.

The chemical analyses have not yet been made of the soil samples collected from the Eastern Coalfield. The second bottoms that have been so long under cultivation will doubtless be found to be decidedly acid when analyzed.

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